Sediment Control In-Front of El-Kureimat Power Plant Intakes

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Abstract: Sedimentation process at the entrance of river intake structures is an imperative issue. If there should arise an occurrence of power-plants that utilization flow cooling water, sediment deposition decreases the pulled back limit, makes harms the pumping framework and causes halfway or full blockage of the intake. Sediment blockage may cause ceasing of the plant. This examination displays and breaks down the issue of sedimentation at water intake of El-kureimat control plant utilizing a 2 dimensional computational model, iRIC. Four alternatives were tried under three flow conditions, fifteen numerical runs were completed to characterize a progressive arrangement from hydro-dynamical and morphological perspectives. The model was calibrated and verified using field measurements. The results were contrasted with the basic case. Connecting the small formed island and the downstream of El-Kureimat Island to bed level 23.0m, prompted increment the average velocities by 60%, 22.1%, and 30.9% for Min, Dom, and Max flow conditions individually prompting sediments removal in front of intakes of the power plant. Thusly, it was introduced as a practical answer for sediment control at water Intake of El-kureimat power plant.

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1. Introduction

The Nile River is subjected to various floods with a generally wide varieties going from low to high. Despite the fact that high floods have their symptoms on riverbanks, water powered structures and riverbed. Low floods have numerous other basic results on the accessibility of water assets and low water levels. The reactions of low flows are many. The cases of these symptoms are the water supply lack, navigation problems, and some local sedimentation issues.

Practically speaking, there are a wide range of purposes for water utilize, for example, water system, drinking, cleaning, and cooling. This water is removed from various intakes from dynamic fresh water sources in the waterways or flows. The inlets of these pipes are normally submerged to guarantee a nonstop water supply. On the off chance that such submergence isn't sufficiently deep or the water surface is fluctuating causing the pipe submergence depth to wind up littler, issues of vortexing and cavitation are constantly anticipated.

The system of sediment development in the fluvial condition has been widely analyzed; anyway deterministic methodologies that assessing disintegration and sedimentation rates were hampered by vulnerability in an extensive number of flow and sediment related factors. Numerous examinations were associated with controlling the sedimentation forms in the region of intensity plants intakes. One of these procedures was using the submerged vanes. The vanes work by producing bed shear stresses and cause an adjustment in the distribution of velocity, depth, and sediment transport in the zone influenced by the vanes. The principal known endeavors to build up a hypothetical outline were examined by Odgaard and Kennedy [1] and Odgaard and Spoljaric [2], Odgaard and Wang [3], [4], Wang [5], Fukuoka and Watanabe [6]. These endeavors were gone for outlining an arrangement of vanes to stop or decrease bank erosion in flow bends.

As to controlling of sedimentation forms in the region of intakes, Odgaard et al., [7], Wang et al., [8], Sadjedi et al., [9], and Hojjat Allahyonesi et al., [10], Sruthi et al., [11], experimentally demonstrated the usage of submerged vanes showed a superior in this field.

Consolidating different philosophies notwithstanding the vanes for sediment control, Tasuaki and Fred [12], displayed the outcomes from five physical hydraulic model that was done for the reasons for sediment control at water intakes along sand-bed waterways. They inferred that using arrangement of submerged vanes notwithstanding a sediment obstruction introduced between the vanes and intake was a successful arrangement.

Frank et al., [13] experimentally examined sediment control at water consumption for large thermal-power station on a small river. They depicted how the sediment issue was effectively controlled by methods for adjustments to the zone before the intake and the upstream riverbank. The changes included disintegration advancing vanes and a skimming divider, together with realignment of the riverbank upstream of the intake.

Thanos [14], connected 2D hydrodynamic model, to discover elective techniques for anticipating sediment aggregation at the intake structure. Additionally, propose a remediation measures to control the sediment disintegration process well upstream of intake. The outcomes were controlled to the improvement of a waterway reclamation procedure that yields fruitful sediment for an assortment of flow conditions.

Basim et al., [15], utilized the air flow technique to control the suspended sediment at water intake. The productivity of the strategy has been examined hypothetically utilizing dimensional examination and experimentally in the research facility. The examination detailed that as the air discharge expanded and sedimentmedian diameter diminished, thusly the relating effectiveness expanded.

Ahmed [16], considered the issue of sedimentation at water intake of Rowd El-Farag pump station utilizing a 2-D computational model. The examination inferred that the utilizing of dredging as a supportable answer for sediment control at water intake of Rowd El-Farag pump station in spite of the fact that this arrangement was costly.

Rowida [17], investigate the adequacy of an arrangement of various techniques to alleviate the sedimentation problem in front of El-kuraimat thermal power plant utilizing a 2-D numerical model. The simulation that was carried out for 2-years, and concluded that joining two islands in the vicinity of intakes showed a good performance in solving this problem.

Abd Elhamed and Sherif [18], numerically inspected the distinctive techniques to limit the sediment stack reach to the pump suction point for the "El-Qatee" lifting plant. The investigation demonstrated that the arrangement and measurements of intake channel with its approaching channel have been adjusted so as to hydraulically fulfill both the sedimentation problem and the suction blocking counteractive action.

In this study, a 2-D numerical model, was connected to explore the adequacy of an arrangement of contrasting alternatives to remove the sedimentation in the region the pumps intake of El-kureimat power plant over 5-years run time duration. Additionally, prescribing an answer in light of hydrodynamic and morphological perspectives.

2. Site description and problem definition

The El-Kureimat power plant is situated on the east bank of the River Nile 95km south of Cairo in a desert village called EL-Kureimat, fig.1.

Numerous islands were found at the flow limit inside the overviewed achieve; the greatest one is called El-kureimat Island which is around 4300m long and 1300m as normal width. The downstream limit of this island is situated around 500m upstream of the proposed site for the plant.

Another island was found at the area under the examination which is called Beni-hideir Island. This island isolates the flow into two branches primary and auxiliary. The primary channel at the correct side of the flow with an average active width of 600m, while at the left side the secondary branch is situated with 95m normal width. In any case, because of the limit of weeds around there the dynamic width of this branch has diminished to 50m.

By the activity of time and river morphological changes; another island was framed before the southern piece of the site. Thus, the primary channel was partitioned into two sections. The east channel which is in front of the power plant intake and the west channel that is between the formed island and Beni-hideir Island, fig.1. Consequently, a lot of sedimentation was shaped in front of the current intake.

The sediment that entering the pump station causes blockage of the waste rack and related vibration notwithstanding wearing of the pump impellers; henceforth the pump impellers ought to be supplanted every 2 or 3 years and amid high season. Additionally, because of the noticed decrease in velocity; skimming vegetation were gathered, subsequently goes about as sediment traps which thus expanding the deposition in this locale.

3. Problem in hand

3.1 Bed material sample

The samples of the bed material alongside the investigation reach were collected by (HRI) [19]. The bed material of the examination territory comprises of sand and sediment. The fine sand was extended somewhere in the range of 60.61% and 88.06% of the bed material sample then again; the level of sediment was gone somewhere in the range of 0.82% and 14.45% of the bed material sample.

3.2 Model development

iRIC “international River Interface Corporative" is 2-D numerical model was utilized to evaluate the current sedimentation issues and investigate the consequent therapeutic measures. iRIC comprehends the Navier Stokes equations for an incompressible liquid, under the shallow water and the Boussinesq presumptions. In the vertical momentum equation, the vertical increasing velocities are dismissed, which prompts the hydrostatic pressure equation. The arrangement of partial differential equations in blend with an appropriate set of initial and boundary conditions was solved on a finite difference grid.

A comprehensive knowledge of iRIC model is important to get a solid outcome for the morphological expectation in the zone of intrigue. iRIC is appeared to perform well in a few hypothetical, research facility, and genuine circumstances. Computer modeling of sediment transport designs was by and large perceived as a significant instrument for comprehension and foreseeing morphological advancements. This model can be utilized with great exactness in the field of the hydrodynamics.

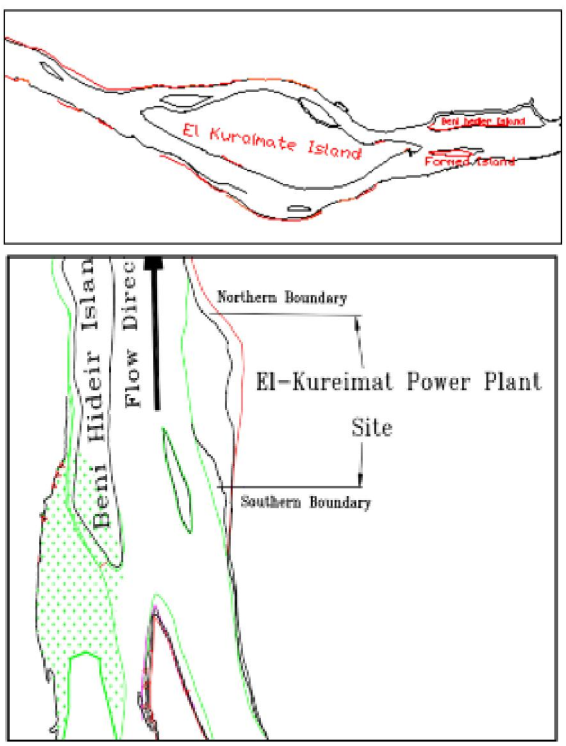

Fig.1: General layout for the site of El-kureimat power plant

3.2.1 Mesh generation

The initial step to utilize (iRIC) model was to generate a mesh to speak to the computational domain and discretize the governing equations. A work made out of 102 by 24 lines (J & I) was representing the study reach of 8.5km length and 2.0km as average width, Fig.1.

A quadratic fine framework was built up to reenact the contemplated region. The mesh lines were dense around the intake of the pump station. Likewise, the discharge and water level were set as upstream and down stream boundary conditions respectively.

3.2.2 Model validity

To guarantee the legitimacy and the exactness of the utilized numerical model; a calibration and verification processes should be explored; the bathymetric overview of the River Nile and velocity estimations at various areas in the region of El-kureimat Island were utilized for this reason, Fig.2.

The calibration procedure of the hydrodynamic model was done by looking at the model yields with respect to the velocity estimations by the comparing esteems acquired from field. The hydraulic parameters utilized in adjustment were the discharge, the upstream, and the downstream water levels of $1127 m^3/s$, 22.4m and 21.6m, separately. The examination was given all through eight cross sections. However, in the present investigation the velocity distribution were just introduced at cross sections No. 2, 3, and 6 as illustrations (Figs 3-5). It ought to be specified that these cross sections were deliberately chosen to characterize the entire district involved in the research, in other words upstream and downstream El-kureimat Island.

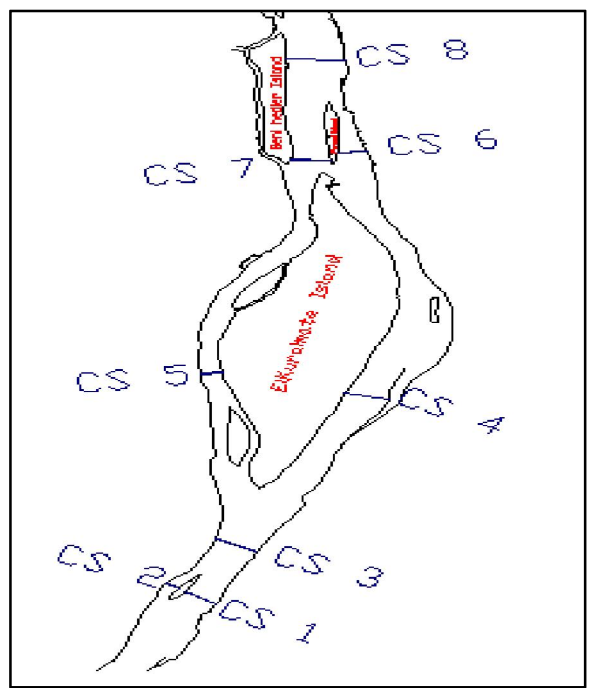

Fig.2: Locations of measured velocities cross sections

From figures investigations it was noticed that the differences between the measured and calculated velocities showed good agreement. The percentage of velocity errors were under estimation of 7.11%, 9.73%, and 4.27% at cross sections 2, 3, and 6 respectively.

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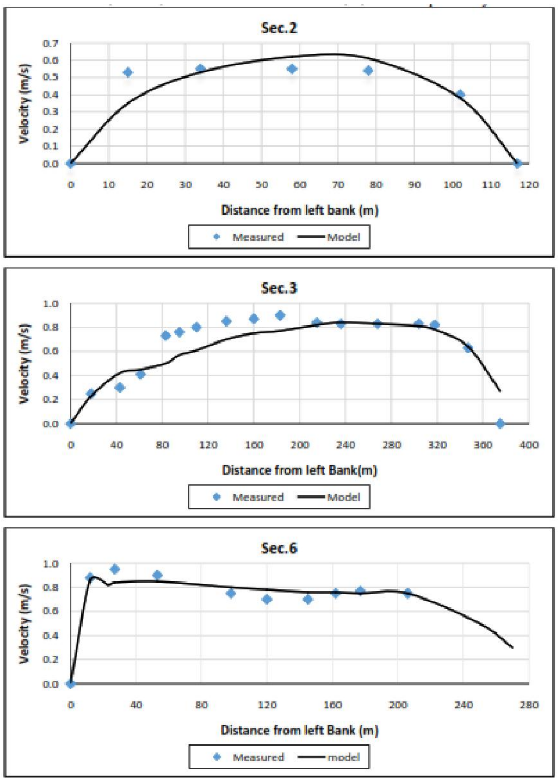

Fig.3: Comparison between the measured and the predicted velocities at different cross sections

After running the numerical model; figure 4 was plotted to show the velocity distribution introduced as shape maps and vectors at cross sections 2, 3, and 6, individually. It was seen that the velocity magnitudes were gone from 0.0 to 1.33m/s. Concentrating on the base velocity values, it was discovered that they were firmly stale in the region of the two banks which concurred with the results in fig. 3 as the velocity magnitude was 0.0m/s precisely at the left bank. Then again, the most extreme velocities were seen in the tightest width in the channel and frequently packed in the mid width which was found at sections 2 and 3. However at section 6, the most extreme velocities were seen near the right bank. That was because of an amount of flow passed the contracted width between the formed island and the right bank, subsequently the velocity increased and exits acting as a water jet of 1.33m/s velocity value.

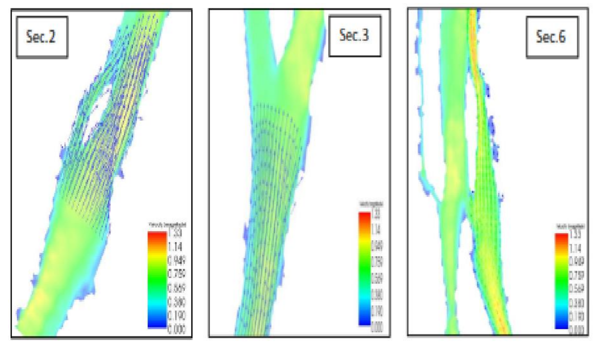

Fig.4: The velocity contours and vectors

3.3 Model application and tested scenarios

To improve the sedimentation issue in front of El-Kureimat power plant; 4 distinct choices were numerically tried. Every alternative notwithstanding the basic case (with no impedance) was tried under various flow conditions (Min, Dom and Max Flow), table 1.

Table 1: River Hydrograph

Case	Maximum Discharge	Dominant Discharge	Minimum Discharge
Discharge (m^3/s)	2245	1190	550
Water Level (m)	23.37	21.63	20.05
Duration (month)	2	9	1

The tried choices were researched given that to increase the conveyance of the east channel for the benefit of the west channel, by increasing the entrance width at the downstream end of the small formed island in front of the power plant intake. The alternatives were exhibited in figure 5 and they were as following:

- **Alternative-1:** Constructing one deflector of 100m length at the west channel.
- **Alternative-2:** Dredging the bed level in the eastern channel in front of the intake up to 17.5 m; which is the minimum water level in the study area.
- **Alternative-3:** Connecting the small formed island to the downstream of El-Kureimat Island to bed level 23.0 m.
- **Alternative-4:** Trimming a part of the small formed island in front of the power plant intake the shape by then dredge the cut area level of 16m.

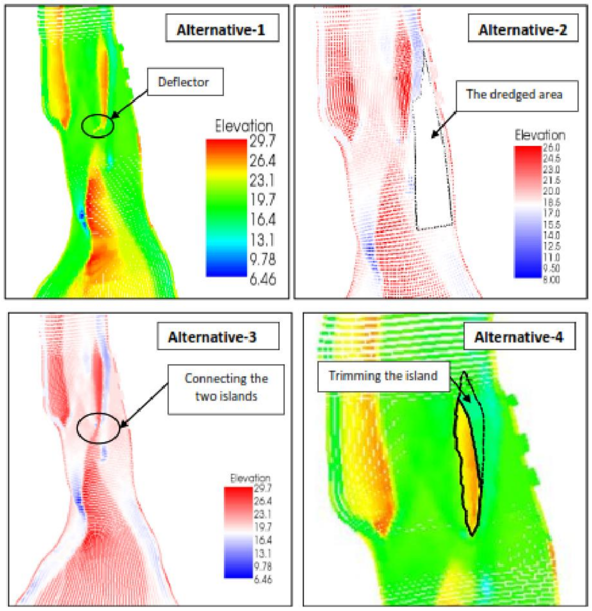

Fig.5: The geometry of alternatives

4. Model results and analysis

4.1 Hydrodynamic simulation

The hydrodynamic recreation was centered around the impact of every alternative on the discharge and velocity. The outcomes demonstrated that connecting the two islands (alternative-3) demonstrated a superior from the hydrodynamic perspective contrasted with different choices. It was seen that the discharge was increased compared the basic case in the eastern channel by 7%, 16.9%, and 15.8% in the case of Min, Dom, and Max flow separately. The increase of the discharge subsequently prompted increment in the average velocities in the region of intakes. Emphasizing on velocity, the outcomes showed that alternative-3 was effectively increases the average velocities by 60%, 22.1%, and 30.9% for Min, Dom, and Max flow separately. Thus, the sedimentation forms were thus diminished.

4.2Morphological simulation

The second stage was focused on the morphological impact of the tested alternatives contrasted with the basic case over a long run time span (5-years) for the dominant flow conditions. iRIC-NAYS2DH is the numerical module that was applied for this purpose.

The impacts of the tested alternatives were introduced at 3 diverse cross sections that absolutely characterize the region in the vicinity of the plant intake; fig.6. It should be said that the intakes were situated at 840m, 880m, and 920m respectively from the right bank, subsequently the figures that present the impact of alternatives on bed topography were plotted in regards to the pre-specified distances.

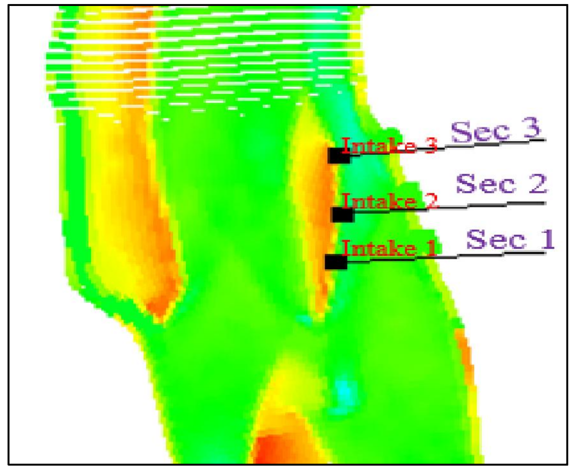

Fig.6: The location of the morphological cross section

To investigate the bed morphological changes brought about each tested alternative at various cross sections in contrasted with the basic case; figures 7-10 were plotted. In addition, tables 2 and 3 were exhibited to summarize the findings of figures 7-10.

Table 2 was focused on the distinctions in bed levels for each alternative in contrasted with the basic case at the locale of pump intakes (i.e. precisely at 840m, 880m, and 920m respectively distances from the right bank). However, table 3 showed the average differences in bed levels from the perspective of normal scour and deposition for the tested alternatives and the basic case at the overall distance from the right bank; to investigate how far the progressions happened in the bed topography due to each alternative. Thusly, the viability of each alternative on the discharge conveyance was recognized.

Accentuating tables 2, positive and negative signs were discriminated. The positive signs alluded that the bed level was increased for the tested alternative in contrasted with the basic case (i.e. sedimentation forms were build up). While, the negative signs showed that the tested alternative abatements the bed level contrasted with the basic case.

The best alternative was chosen given that the bed level was diminished in the front of pumpin takes for various cross sections to permit more discharge conveyance; increasing the velocity, thus sedimentation processes were decreased.

4.2.1 Morphological influence of alternative-1

The bed levels of alternative-1 notwithstanding the basic case were plotted in figure 7. At sec.1 it was seen that the bed level was increased than the basic case at channel inlet by 1.83%. However, the most extreme impact of alternative-1 was situated at 1240m distance from the right bank where the bed level was 1.72m lower than the basic case. Concentrating on sections 2 and 3, the figure demonstrated that alternative-1 prompted decrease in bed levels at inlet by 0.34% and 4.84% respectively. In spite of the fact that the active impact of alternative-1 however it couldn't be viewed as the best alternative because of the noticed increase in bed level at sec.1.

Accentuating on the general morphological impact of alternative-1, table 3 detailed that the average scour depth was higher than the average deposition height for every single cross section. However, the most extreme impact brought about the tried alternative was situated at sec.3 where the contrast amongst scour and deposition with respect to the total width of the cross section was 0.44m for the scour process.

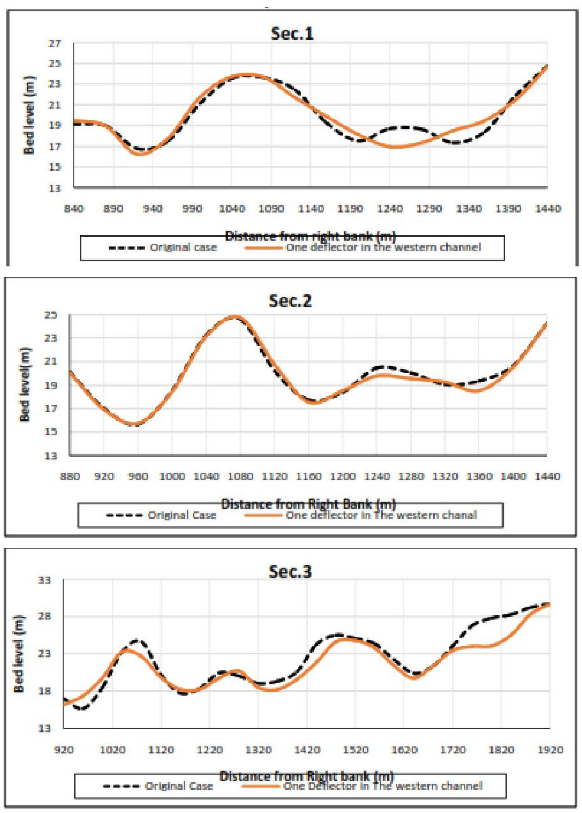

Fig.7: Bed levels at different cross sections in case of basic case and alternative-1

4.2.2 Morphological influence of alternative-2

Figure 8 delineated the impact of alternative-2 on the bed topography contrasted with the basic case. Investigating fig.8 and table 2 it was demonstrated that alternative- 2 displayed an upright execution from the perspective of decreasing the bed level than the basic case at sections 1 and 2 by 7.34% and 16.11% individually at the plant inlet. However at sec.3, the alternative-2 was not ready to diminish the bed level than the basic case; the bed level was seen to be increased by 9.52%. Thusly, alternative- 2 was not viewed as the best choice.

Underlining the general bending because of the tried alternative contrasted with the basic case, table 3 commented that the average scour depth was higher than average deposition height for all tested cross sections. Joining the explanations of figure 8 and table 3 to investigate the most extreme morphological impact because of the tested alternative contrasted with the basic case, it was found at sec.3; where the general distinction between the average scour and deposition was remarkable.

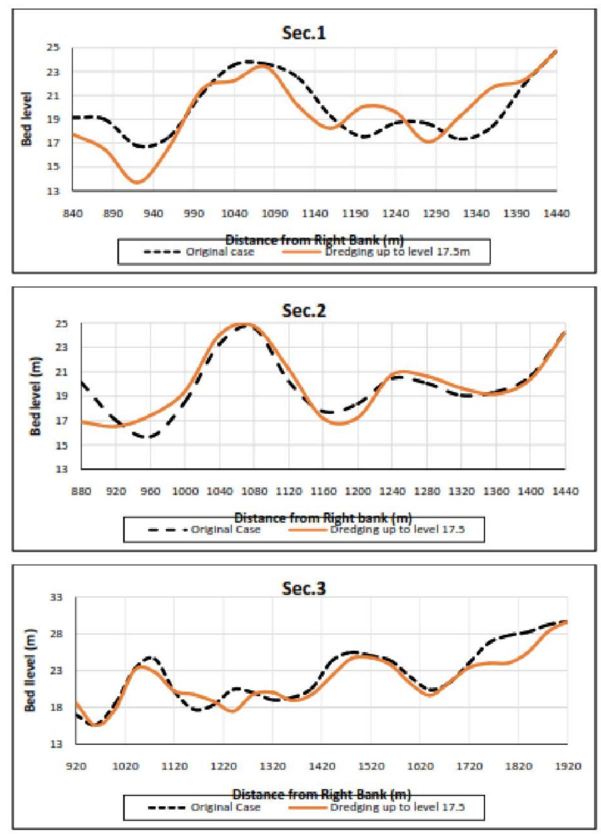

Fig.8: Bed levels at different cross sections in case of basic case and alternative-2

4.2.3 Morphological influence of alternative-3

Figure 9 demonstrated the bed level varieties for the basic case and the comparing brought about alternative-3. The observations pronounced that the bed level was diminished than the basic case in the region in the vicinity of plant intakes for all tested cross sections. That can be clarified as in the wake of associating the small formed island to the downstream of El-Kureimat Island, the gap in between has been closed, subsequently the water conveyance all through was anticipated. Thusly, the discharge went through the eastern channel of El-Kureimat Island proceeds specifically towards the eastern channel of the small formed island with no spillage from the hole between the two islands. In like manner, the discharge and velocities were increased contrasted with the basic case; prompting a progressive movement for sedimentation formed in the front of intakes.

The base and greatest decrease in bed levels were 1.61%, and 5.59% and situated at sec. 1 and 3 respectively, which was unmistakably featured in table 2. Highlighting the general aggravation because of the impact of alternative-3 from the perspective of collective scour and statement; table 3 commented that at sec.1, the contrasts between the average scour and deposition elevations was vanished. Concentrating on sec. 2, and 3 it was seen that the average scour depths were 0.07m and 0.39m greater than the average deposition heights statures separately. Consolidating the results of fig.9, tables 2 and 3 it was reasoned that, associating the two island exhibited an appropriate answer for the sedimentation procedure. The current findings showed a good agreement with [17].

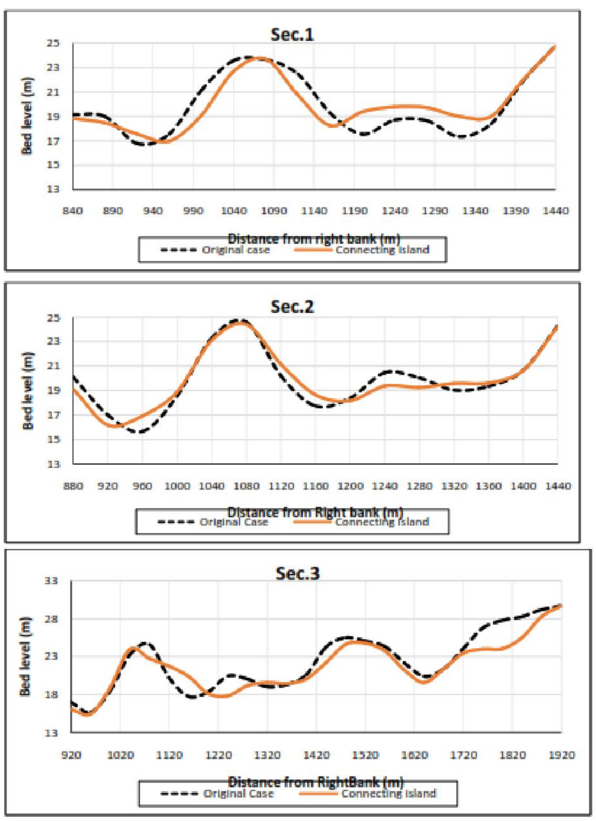

Fig.9: Bed levels at different cross sections in case of basic case and alternative-3

4.2.4 Morphological influence of alternative-4

To clear up the impact of trimming a part of the small formed island in front of the power plant and dredge the cut area to level of 16m "alternative-4"; fig.10 was plotted. Focusing on the region in the vicinity of the plant intake, it was seen that the bed level was increases than the basic case for sections 1 and 3 by 1.81% and 5.50% individually. However, the alternative demonstrated a decent execution with respect to sec.2, as the bed level was diminishes by 7.30%. Investigating the general contortion for the tried alternative on the bed topography including the total width of each cross section contrasted with the basic case; table 3 showed that the average scour depth was more noteworthy than the normal sedimentation height for every single cross sections. Also, the minimum and most extreme contrasts in bed levels were situated at sections 1 and 3 respectively.

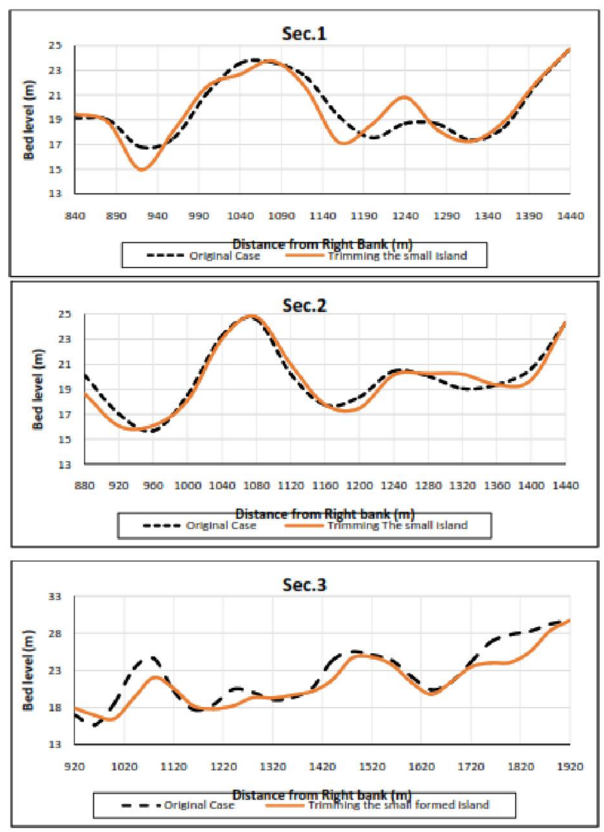

Fig.10: Bed levels at different cross sections in case of basic case and alternative-4

Table 2: Percentage of increase or decrease in bed levels for different alternatives in front of pump intakes compared to the basic case

Alternative No. \ Sec No.	1	2	3
Alternative-1	1.83%	-0.34%	-4.84%
Alternative-2	-7.34%	-16.11%	9.52%
Alternative-3	-1.61%	-4.92%	-5.59%
Alternative-4	1.81%	-7.30%	5.50%

Table 3: Average difference in bed levels for different alternatives overall the width of cross section compared to the basic case

Alternative No. \ Sec No.	1	2	3
Alternative-1	-0.15	-0.05	-0.44
Alternative-2	-0.11	-0.10	-0.30
Alternative-3	0.00	-0.07	-0.39
Alternative-4	-0.13	-0.40	-1.00

5. Conclusions

The power station was strategically placed close to the River Nile that gives the water essential for plant operation. The waterway has likewise encouraged the conveyance of equipment and materials to the site during and after construction. El-kureimat control plant has had a background of chronic issues with waterway sediment development in front of the intake structure. The current study inferred that as a manageable answer for the control of the sediment deposition in the region of the pump station intake, it is advisable to connect the small formed island to the downstream of El-Kureimat Island to bed level 23.0m "Alternative-3". As compared to the basic case, the discharge was increased in the eastern channel by 7%, 16.9%, and 15.8% for Min, Dom, and Max flow respectively. Additionally, the normal velocities were increased by 60%, 22.1%, and 30.9% for Min, Dom, and Max flow individually. The bed level was decreased by 1.61%, 4.92%, and 5.59% in the region of pump intake at sections 1, 2, and 3 respectively.

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